geocentric angles) between satellites as they converge in the polar region. Station keeping tolerances must be accepted to prolong propulsion fuel; these tolerances will corrupt the idyllic coverage portrayed in the CCI application in a manner that reduces or eliminates the overlap among almost half the satellite footprints. For example, if the mean phasing between satellites in adjacent, co-rotational planes were set at 3.75° offset (rather than the proposed 15°) in order to minimize collision probabilities, then large gaps in coverage would occur frequently at low and mid-latitudes for substantial periods of the time.

CCI claims that elevation angles will exceed 7.5° at latitudes greater than 25° for 100% of the time. Application, Appendix A, at 23. This visibility statistic is erroneous and is of little value in evaluating the performance of the proposed Aries system. Specifically, as explained in relation to system coverage, station keeping objectives needed to minimize the probability of colission among Aries satellites and to conserve propulsion fuel will reduce or eliminate overlap among satellite footprints. It is axiomatic that the minimum elevation angle to Aries satellites also would be reduced and that no visibility to any satellite will be possible as a coverage gap transits the area being served. The visibility statistics that are needed in order to evaluate the expected performance of Aries include cumulative distributions of elevation angles to an accessible Aries spacecraft and associated key azimuth slew statistics for various latitudes spanning the intended service area. These statistics must be based on a realistic station keeping objective for the Aries system that is acceptable from the standpoint of safety of life and property in space.

2. Other System Design Problems

(a) Electrical Power Systems

CCI has provided a general description of the electrical power system for the proposed Aries spacecraft, and included preliminary specifications of the minimum, average, and peak power available for the communications payload. Application, Appendix A, at 8-10. CCI did not, however, include a description of the power system dynamics that is needed to evaluate the performance of such a power-limited low-Earth-orbit satellite. CCI admits to the need for a power-load shedding capability, but does not go on to explain that this load shedding must include shedding of communications channels that may be needed even during periods of moderate demand. Specifically, each Aries satellite will experience a solar eclipse of up to about one-half hour (35 minutes) on every orbit having equatorial crossings within several hours of local noon time. While eclipsed, the satellite must draw upon battery power alone to provide service and to accomplish housekeeping. During the maximum length eclipse, only about 67 watts (average) can be drawn from the battery (20% discharge) if it is to have a substantial probability of lasting five years, which yields only about 42 watts DC for the 2.4 GHz transmitter. In turn, disregarding all other Aries capacity constraints, an average of less than ten (10) physical channels could be sustained during maximal eclipse (which is too few channels to use on voice activity factors to accommodate more than ten users).

To put this severe capacity problem in perspective, consider Aries users dispersed throughout the U.S. Pacific Time Zone between the hours of 10 PM and 2 AM PST. At this time, the closest plane of Aries satellites could be in the midst of maximal eclipse. These satellites will have entered eclipse while ascending from over South America (i.e., areas over which the spacecraft batteries may have been partially depleted while for service outside the U.S., if permitted). It is reasonable to expect that of the over-100,000 Aries subscribers envisioned by CCI, twenty (20) users located in the Pacific Time Zone may have a communications requirement at the same time. Because only one Aries satellite (if any) would be visible to these users, CCI would be faced with a dilemma of either blocking access by some of these users (in order to preserve battery power for subsequent users as the satellite ascends towards Alaska) or accommodating all twenty users, thus risking that either some or all of these users must be "shed" or subsequent users must be blocked (in order to prevent excessive battery discharge and concomitant loss of battery life). Clearly, this capacity problem is sufficiently severe to be considered a reliability problem.

(b) Service Restoration

The proposed Aries space segment consists of 48 satellites, each of which has subsystem redundancy and longevity that are expected to yield a lifetime of only five (5) years. Application, Appendix A, at 20-21. Thus, severe communications outages will occur because satellite failures will occur, and these outages will occur more frequently towards the end of the five-year life cycle and even more frequently after five years if CCI were to attempt to extend satellite lifetimes. CCI states its intention to replace failed satellites via new launches rather than via use of on-orbit spares or off-loading to other compatible satellites. Application, Appendix A, at 27. Consequently, substantial time will pass before failed satellites are replaced and, at and beyond five years into the Aries life cycle, there is a significant probability that two or more satellites will be unusable at the same time. At any given location in the Aries service area, each failed but unreplenished satellite causes outages several times a day with outage durations of up to eleven (11) minutes. Thus, on the basis of service restoration considerations alone, the Aries system is simply too unreliable for many MSS applications where real-time communications are required.

II. TRW, INC.

A. Potential Interference to Other Services

1. Radio Astronomy

TRW claims its system can share with each radio astronomy observatory operating at 1.6 GHz by assigning all proximate communications users in the upper two-thirds of the 1610-1626.5 MHz band and by assigning RDSS in the same fashion or in the lower third of the band (co-frequency with radio astronomy) when they are known to be sufficiently distant from observatories. TRW Erratum, Appendix C. TRW's analysis is severely flawed because the separation distances needed between all users of the lower Odyssey sub-band and each radio astronomy observatory are not available throughout most of CONUS. Specifically, over 400 miles separation would be needed between an aircraft using Odyssey in the lowest frequency sub-band and a radio astronomy observatory, as shown by the calculation in Table 8. Similarly large distances could be needed for land and maritime users of Odyssey when operating at the maximum EIRP levels. Given these separation requirements, Table 3 shows that the six U.S. radio astronomy observatories using the 1.6 GHz band are dispersed in a manner that precludes Odyssey use of the lowest proposed sub-band (1610-1615.6 MHz) over most of CONUS.

2. Fixed Service

TRW presents an analysis of sharing between Odyssey downlinks and receivers in the fixed service in the 2483.5-2500 MHz band that includes only PFD calculations but does not address the levels of received interference (Appendix C, at C-10 to C-13). Using TRW's own PFD calculation, Table 9 shows that Odyssey would cause interference levels that are 12 dB and 26 dB in excess of the permissible levels for analog and digital links when an Odyssey satellite is located within several degrees of the mainbeam of the fixed station. Thus, Odyssey frequently will cause severe interference to receivers in the fixed service.

From the above findings, it can be seen that the effect of a dense constellations of non-geostationary satellites (e.g., Odyssey) is to significantly reduce the quality (availability) of communications in the fixed service. Specifically, degradations would occur from (1) the decrease in fixed service link margins, which increases the probability of unavailability due to fading of the desired signal, and (2) the low carrier-to-interference power ratios that occur every time a satellite passes near or through the fixed receiver mainbeam, which increases the probability of unavailability while desired signals are at unfaded levels. These problems are exacerbated in radio-relay systems in which several receivers would be subject to the interference. In contrast, geostationary MSS systems do not pass through the mainbeams of fixed stations; therefore, fixed station antennas provide a reliable degree of discrimination to mitigate the effects of PFD from geostationary satellites. The angular separation between the mainbeam of a fixed station and non-geostationary satellites operating in the MSS is simply too small for significant time percentages to yield a manageable frequency sharing situation under the current PFD limits, let alone under relaxed limits.

In its Petition, TRW proposes a 10 dB relaxation of the current power flux density ("PFD") limit in the 2483.5-2500 MHz (space-to-Earth) band in order to enable its system to provide capacity sufficient for mobile-satellite service ("MSS") including voice communications.[5] TRW claims that an NTIA study of satellite systems in the 2025-2300 MHz frequency range shows that higher PFD levels from non-geostationary MSS satellites should have little or no effect on other users of the 2483.5-2500 MHz band.[6] TRW's claim is totally incorrect, and the evidence suggests that the existing PFD limit is inadequate to protect terrestrial services from any of the proposed non-geostationary MSS systems. Specifically, the NTIA study addressed satellite systems that are significantly more compatible with terrestrial systems than are the proposed non-

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5 TRW admits that the Odyssey maximum PFD exceeds the RR limit by about 7 dB at low elevation angles. TRW Application, Erratum, Appendix C, Attachment 1.

6 TRW Petition, at 12-13. The "NTIA study" cited by TRW is "Assessment of Satellite Power Flux-Density Limits in the 2025-2300 MHz Frequency Range, Part 2," NTIA Report No. 84-152, July 1984. Part 1 of that study is also relevant (same title, NTIA Report No. 83-135, October 1983).

geostationary MSS systems. The fact is, the interference trends determined by NTIA for various deployments of non-geostationary satellites indicate that application of the current PFD limits to MSS systems using dense constellations of non-geostationary satellites will result in harmful interference to terrestrial systems. In addition, the proposed relaxation of PFD limits would create an interference environment that would virtually preclude operation of conforming RDSS systems.[7]

The NTIA study cited by TRW does not support the proposed relaxation of PFD limits for non-geostationary satellites and, in fact, indicates that non-geostationary MSS systems will produce unacceptable interference even if they conform with the current PFD limits. Specifically, NTIA's study shows that a relaxation of PFD limits may be acceptable for a sparse, random deployment of up to eight non-geostationary satellites at 300-1200 km altitude that have a cumulative total visibility of less than 10% of the time and which generate composite emissions that do not produce noise-like interference. In contrast, the proposed non-geostationary MSS systems attempt to provide visibility for 100% of the time using from 12 mutually-synchronous satellites at higher altitudes (e.g., 10,371 km in the case of TRW) to 48 mutually-synchronous satellites at lower altitudes,

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[7] Systems in the radiodetermination-satellite service ("RDSS") must conform to a number of technical standards, including the PFD limit that is the subject of proposed relaxation with respect to MSS systems. MSS systems operating with 10 dB higher PFD than RDSS systems would severely limit the capacity of the RDSS systems.

and the emissions from these MSS satellites may produce more onerous noise-like interference. NTIA's study indicates that (1) use of (1) higher-altitude non-geostationary orbits (e.g., TRW); (2) operation of greater than the assumed number of non-geostationary satellites (any of the proposed non-geostationary MSS systems); or (3) use of emissions producing noise-like interference each would substantially increase the interference received by terrestrial systems.[8] Thus, NTIA's study indicates that the current PFD limit in the 2483.5-2500 MHz band may be too lenient to protect terrestrial systems from harmful interference.

Even if it were feasible to relax domestic PFD limits for non-geostationary MSS satellites, the elevated PFD levels would illuminate the territory of other administrations whose terrestrial systems would suffer harmful interference. The "footprints" of satellite antenna beams generated in the 2483.5-2500 MHz band by the proposed non-geostationary MSS satellites range from 800 km (500 miles) in diameter to full Earth coverage. These beams could illuminate the territory of administrations throughout North America and as distant as Eastern Europe, South America, and Asia at the same times they exceed internationally permissible PFD levels. Thus, unilateral relaxation of PFD limits by the U.S. could lead to harmful interference to terrestrial systems operated by other administrations.

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[8] See NTIA Study, Part 2, at 54a through 56 and 62-71.

3. Radionavigation-Satellite

TRW's application omits any consideration of the interference that Odyssey would cause to radionavigation-satellite systems operating in the 1610-1616.5 MHz band. As shown by the calculations in Table 10, Odyssey would cause harmful levels of interference to the GLONASS system even if it were assumed optimistically that 20 dB of GLONASS processing gain is available to reduce the effects of interference. Specifically, Odyssey users operating with moderate shadowing would cause potentially harmful interference to GLONASS receivers located 59 km (37 miles) away. Clearly, this is unacceptable to the aeronautical community, which is relying on interference-free access to GLONASS as part of the Global Navigation Satellite System.[9] Of lesser but

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9 See, for example, The Glonass System Technical Characteristics and Performance, FANS/4-WP75, ICAO, May 6, 1988. See, also, the ICAO position on issues of vital interest to international civil aviation to be decided at the 1992 ITU World Administrative Radio Conference (WARC-92), Doc. No. ALOC-025 (17 May 1991), which states (at A-36) that

> "The ICAO position [for WARC-92] is that the bands which are used by GPS and GLONASS to provide radionavigation satellite services should be retained without change and continue to be allocated to the radionavigation-satellite and/or aeronautical radionavigation services and should be protected from interference in accordance with, iter alia, Nos. 164, 341 and 953 of the Radio Regulations. Any new service allocations added to the bands must not cause harmful interference to the aeronautical radionavigation services."

still potentially significant consequence is the fact that GLONASS satellites also would interfere with reception by Odyssey satellites.

4. RDSS

TRW presents analyses that purportedly show that the interference between Odyssey and geostationary RDSS systems would be acceptable (Erratum, Appendix C). TRW's analysis is flawed in that interference from Odyssey's 2.4 GHz downlinks is apparently overlooked. Because Odyssey would operate downlinks at PFD levels that exceed geostationary RDSS system PFD levels by at least 5 dB to 7 dB, Odyssey would substantially reduce the capacity of geostationary RDSS systems.

5. MSS

In its interference analyses, TRW completely overlooks the fact that the 1610-1626.5 MHz band may be used in geostationary MSS systems. As shown by the calculations in Table 11, the proposed Odyssey uplinks would generate C/I ratios between -4.5 dB and 5.4 dB in AMS(R)S uplinks under various operating conditions at times that Odyssey is operating near its full-capacity levels. These C/I levels would result in complete disruption of MSS communications via geostationary satellites.

B. Capacity

TRW states that Odyssey can provide capacity for 4600 voice channels in North America. Application, at 6. This capacity level, however, ignores the fact that Odyssey cannot use uplinks below 1616.5 MHz and downlinks at the high proposed PFD levels. Specifically, Odyssey uplinks operating below 1616.5 MHz would cause harmful interference to radio astronomy and radionavigation-satellite services, and so, the true potential capacity of Odyssey should be adjusted to reflect uplink operation in only the 1616.5-1626.5 MHz band. In the downlink direction, Odyssey satellite emission power (and capacity) would have to be reduced by 7 dB in order to conform with existing PFD limits; a further reduction by at least 10 dB would be needed to ensure that harmful interference to the fixed service would be precluded. As shown in Table 12, these adjustments to capacity would result in total Odyssey capacity levels in North America of less than 53 channels.

III. ELLIPSAT

A. Interference to Systems in Other Services

1. Ellipso Violations of Power Limits

AMSC already has demonstrated that Ellipso I power levels would exceed the applicable uplink EIRP and downlink PFD levels.[10] The parameters proposed for Ellipso II also exceed the applicable power limits. Specifically, as demonstrated by the calculations in Table 13, Ellipso II feeder link uplinks in the 1610-1626.5 MHz band would exceed the EIRP limit by 2.5 dB. Likewise, as demonstrated by the calculations in Table 14, Ellipso II downlinks in the 2483.5-2500 MHz band would exceed the PFD limit by 5.8 dB.

2. Interference to Other Systems

(a) Radio Astronomy

Ellipsat claims it will obtain a frequency sharing agreement with the radio astronomy community that is similar to the RDSS operating agreement. Because the Ellipso system differs substantially from RDSS systems, however, the Ellipso II system is incapable of

[10] See Response of American Mobile-Satellite Corporation, In the Matter of the Applications of Ellipsat Corporation and Motorola Satellite Communications (filed August 5, 1991), Technical Appendix, at 3-5.

sharing with radio astronomy on an interference-free basis.[11] As shown by the calculations in Table 15, an Ellipso II aircraft earth station operating within or near the radio astronomy band would have to be located over 680 km (425 miles) from a radio astronomy observatory. Similarly large distances could be needed for land and maritime users of the Ellipso II system in light of the fact that several users could simultaneously interfere with a radio astronomy receiver. Given the separation distances required between Ellipso earth stations and radio astronomy observatories, the six U.S. radio astronomy observatories using the 1.6 GHz band are dispersed in a manner that virtually precludes Ellipso II use of the lower portions of the 1610-1626.5 MHz band (see Table 2).

(b) Fixed Service

Based on the preceding PFD calculation for Ellipso II satellites (Table 14, Table 16) shows that Ellipso II would cause interference levels that are 11 dB and 25 dB in excess of the permissible levels for analog and digital links when an Aries satellite is located within several degrees of the mainbeam of the fixed station. Thus, Ellipso II will cause harmful levels of interference to receivers in the fixed service for substantial percentages of the time.

Because the Ellipso I system also would cause unacceptable interference to the fixed

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[11] See Petition to Deny of the Committee on Radio Frequencies of the National Academy of Sciences, in re the Applications of Motorola Satellite Communications, Inc. and Ellipsat Corp., (filed June 3, 1991), at 2-6.

service, Ellipso II would greatly exacerbate the interference problem. The angular separation between the mainbeam of a fixed station and the non-geostationary Ellipso satellites is simply too small for significant time percentages to yield a manageable frequency sharing situation under the current PFD limits, let alone under relaxed limits such as proposed by TRW.

(c) Radionavigation-Satellite

As shown by the calculations in Table 17, Ellipso II operations below 1616.5 MHz would cause harmful levels of interference to the GLONASS system even if it were assumed optimistically that 20 dB of GLONASS processing gain is available to reduce the effects of interference. Specifically, Ellipso II users would cause potentially harmful interference to GLONASS receivers located 500 km (312 miles) away. Clearly, this is unacceptable to the aeronautical community, which is relying on interference-free access to GLONASS as part of the Global Navigation Satellite System. Of lesser but still potentially significant consequence is the fact that GLONASS satellites also would interfere with reception by Ellipso II satellites.

(d) Mobile-Satellite Service

Ellipsat completely overlooks the fact that a number of geostationary MSS system operators may need to implement band 1610-1626.5 MHz in their systems. As shown by the calculations in Table 18, the proposed Ellipso II feeder link uplinks would generate

C/I ratios between -2.5 and 0.3 dB under various AMS(R)S operating conditions at times that Ellipso II is operating near full-capacity levels. These C/I levels would result in complete disruption of MSS communications via geostationary satellites.

B. Capacity

AMSC already demonstrated that the capacity achievable by Ellipso I would be on the order of one voice channel upon making adjustments that are necessary for sharing of the 1610-1616.5 MHz band with radio astronomy and radionavigation-satellite systems and for conformance with the current PFD limit.[12] Ellipso II is similarly constrained.

Ellipsat indicates that an Ellipso II satellite can provide capacity for 605 voice channels (assuming a voice activity factor of 2.8) and that two such satellites are visible to CONUS users. Application, Appendix B, at 3. Thus, the capacity available to CONUS would be 1210 channels if Ellipsat's claimed satellite coverage and capacity of 605 channels were true. However, Ellipsat's estimate of the Ellipso II satellite capacity fails to take into account that (1) its proposed system (and all other proposed systems) can not use frequencies below 1616.5 MHz, (2) the proposed Ellipso II downlinks cannot operate at the high proposed PFD levels without causing harmful interference to terrestrial services, (3) the Ellipso II link budgets devote too little spacecraft power to each downlink, (4) the frequency reuse plan for Ellipso II compounds its link power

[12] See Petition of AMSC, In the Matter of the Applications of Ellipsat Corporation and Motorola Satellite Communications Inc. (filed June 3, 1991), Technical Appendix, at 56-58.

budget deficiencies, (5) the Ellipso II spacecraft power available during eclipses is probably too low to support a substantial percentage of the claimed loading capacity and (6) two Ellipso II satellites often will not be covering the United States. Thus, even if one were to overlook the fact that two Ellipso II satellites will at many times not be able to address the demand generated in CONUS, the capacity adjustments that would be needed with respect to eclipse conditions, having too few channels to apply voice activity factors, and the reduction in available spectrum resources if Ellipso II were considered as one of seven entrants under the constraints of Ellipsat's multiple entry assertions, the capacity of Ellipso II for service to CONUS is no more than 5 voice channels. See Table 13. Thus, at best, the Ellipso II capacity level is on par with that of "little LEOs" that have been proposed for operation below 1 GHz.

C. Reliability

1. Satellite Coverage and Visibility

AMSC has already demonstrated that the coverage of Ellipso I at mid-latitudes would be less that 30% (which would enable service to CONUS once in a while for about twelve minutes at a time) and that the elevation angles to Ellipso I satellites when they are visible would be below 20° for at least 85.7% of the time (which would result in consistently poor link performance).[13] In its Ellipso II Application, Ellipsat presents no plan for integrating Ellipso II with Ellipso I in a manner that would merge the coverage and visibility attributes of the two systems (assuming Ellipso I spacecraft have not already failed by the time Ellipso II is operational). The orbits and orbit plane configurations of the two systems are substantially different. Thus, Ellipso II is considered to independently provide coverage of the U.S. and the overall Ellipso coverage (assuming the Ellipso I space segment survives into the Ellipso II era) is not the sum of the individual system coverages.

Ellipsat's coverage specifications for Ellipso II bear little or no relation to its system proposal, and its coverage claims appear to be overly optimistic. In its detailed discussion of the selected orbit, Ellipsat states that twelve (12) Ellipso II satellites would achieve better than 95.6% coverage of the U.S. at elevation angles of 5°. Application, at 25. However, Ellipso consists of eighteen (18) satellites instead of twelve (12) satellites, and visibility specification at 5° does not equate to reliable service. Ellipsat provides a series of snapshot coverage views of CONUS, but it is the dynamics of coverage and visibility that must be properly portrayed to enable appropriate performance and reliability evaluations to be conducted. The orbital information in Ellipsat's application is simply too scant to enable independent analysis. In any case, it is extremely doubtful that dual satellite coverage of CONUS would be provided by Ellipso II with appropriate

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[13] See Response of AMSC, In the Matter of Applications of Ellipsat Corporation and Motorola Satellite Communications, Inc. (filed August 5, 1991), Technical Appendix, at 12-14 and 18.

elevation angles and with the flexible geographic distribution of spacecraft power needed to assume that the capacity of two satellites will be available to CONUS during most periods of high demand.

2. Other System Design Problems

a. Electrical Power Systems

As for many other important system parameters, Ellipsat's description of the Ellipso II satellite electrical power system is too vague to enable independent analysis of the power dynamics with respect to eclipse conditions and the consequences on available capacity. Some of the key data that are provided reveal severe problems. Specifically, Ellipsat claims that the solar power sub-system provides 174 watts maximum and full eclipse operation and that the transmitter power is 162 watts. Application, Appendix A, at 2. This would not appear to be possible unless Ellipsat has developed major breakthroughs in technologies for light weight, deep discharge batteries and efficient power systems. The electrical power system of Ellipso I is also dubiously described and has undefined dynamics.[14]

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[14] See Petition of AMSC, In the Matter of the Applications of Ellipsat Corporation and Motorola Satellite Communications, Inc. (filed June 3, 1991), Technical Appendix, at 50-51.

b. <u>Service Restoration</u>

The proposed Ellipso II space segment consists of 18 satellites, each of which has no specified sub-system redundancy. The satellites are expected to yield a lifetime of only five (5) years. Application, Appendix A, at 2. Thus, regardless of any sub-system redundancies, severe communications outages in addition to those resulting from poor coverage will occur because satellite failures will occur, and these outages will occur more frequently towards the end of the five-year life cycle and even more frequently after five years if Ellipsat were to attempt to extend satellite lifetimes. Beyond five years into the Ellipso II life cycle, there is a significant probability that two or more satellites will have failed. Thus, on the basis of service restoration considerations alone, the Ellipso II system is simply too unreliable for many MSS applications where real-time communications are required.

Table 1. PFD produced by Aries Satellites

- Aries satellite antenna input power (full loading): . . . . 19.5 dBW
- Aries satellite antenna gain (towards points having 5° elevation): . . . . 4.5 dBi
- Slant-path range towards points having 5° elevation to satellite: . . . . 3230 km
- Spreading loss: . . . . 141.2 dB/m^2
- Transponder Bandwidth: . . . . 16 MHz
- Power Flux Density: . . . . -117.2 dBW/m^2/16 MHz
- Spectrum Peaking Factor (QPSK): . . . . 2 dB
- Power Flux Density (per 4 kHz): . . . . -151.2 dBW/m^2/4 kHz
- RR Limit (5° elevation): . . . . -154.0 dBW/m^2/4 kHz
- Amount of Violation: . . . . 2.8 dB

Table 2. Separation distance needed between an Aries user and a radio astronomy observatory

- Aries mobile earth station uplink EIRP (Note 1): . . . . 6.0 dBW
- Antenna discrimination toward radio astronomy receiver site: . . . . 0 dB
- Interfering EIRP (Note 2): . . . . 6.0 dBW
- Radio astronomy observatory antenna gain towards Aries user: . . . . 0 dBi
- Permissible single-entry interference power (Note 3): . . . . 230.0 dBW
- Required basic transmission loss: . . . . 236.0 dB
- Required separation distance (Note 4): . . . . 900 km (563 miles)

Note 1: EIRP towards the horizon is assumed, consistent with an aircraft user.

Note 2: The spectral line bandwidth being observed is 20 kHz, according to CCIR Report 224-7. Thus, the entire emission of the Aries earth station can fall within the radio astronomy observation channel.

Note 3: CCIR Report 224-7 indicates that the total permissible interference to the radio astronomy observatory is -220 dBW. However, because numerous Aries users may be operating in the radio astronomy band at separation distances on the order of several hundred miles, no individual interferer should be allocated more than a small percentage of the total permissible interference. Here, it is assumed that a single interferer may contribute up to 10% of the total interference.

Note 4: Estimated by interpolation of curves in CCIR Recommendation 528-2 for 50% of the time and for antenna heights of 15 meters (radio astronomy observatory) and 20,000 meters (aircraft).

Table 3. Separation distances between six U.S. radio astronomy observatories that currently are protected from RDSS (Report and Order, Gen. Docket Nos. 84-689 and 84-690, RDSS, adopted July 25, 1985, Appendix D)

Separation Distances (miles)	Hat Creek CA	Owens Valley CA	VLA NM	Fort Davis TX	Green Bank WV
Owens Valley, CA	302	-	-	-	-
VLA, NM	890	637	-	-	-
Fort Davis, TX	1205	939	320	-	-
Green Bank, WV	2202	2086	1572	1469	-
Arecibo, PR	3567	3362	2733	2473	1595

Table 4. Aries interference to receivers in the fixed service

• Aries PFD towards the Earth horizon:		-151.2 $dBW/m^2/4$ kHz
• Effective aperture of fixed receiver antenna (Note 1):		11.6 dBm^2
• Received interference power:		-139.6 dBW/4 kHz
• Fixed service modulation:	Analog	Digital
• Permissible level of interference (Note 2):	-148 dBW/ 4 kHz	-162 dBW/ 4 kHz
• Required fixed antenna discrimination:	8.4 dB	22.4 dB
• Fixed antenna off-axis angular region where permissible interference is exceeded (Note 3):	2.4°	8.6°

Note 1: Based on antenna gain of 37 dBi, as prescribed in CCIR Report 382.

Note 2: Based on parameters given in CCIR Report 382.

Note 3: Based on $38\text{-}25\log\theta$ pattern of CCIR Report 614. The sidelobe suppression requirements of the FCC would yield larger required off-axis angles.

Table 5. Aries uplink interference to the radionavigation-satellite service

- Maximum permissible interference-to-noise power ratio in aircraft GLONASS receiver due to one Aries uplink (Note 1) . . . . -10 dB
- GLONASS receiver noise power density: . . . . -200 dBW/Hz
- Estimated maximum potential GLONASS processing rejection of Aries signals (Note 2): . . . . 20 dB
- Permissible single-entry interference: . . . . -190 dBW/Hz
- Aries user terminal EIRP density toward GLONASS receiver (Note 3): -33 dBW/Hz
- GLONASS receiver antenna gain toward Aries user terminal: . . . . 0 dBi
- Required basic transmission loss: . . . . 157 dB
- Required separation distance (Note 4): . . . . 500 km (312 miles)

Note 1: Several Aries uplinks could simultaneously interfere with a GLONASS receiver. A single interference power entry that is 10 dB less than the noise power level causes a 0.6 dB reduction in the effective signal-to-noise power ratio. Thus, the interference criteria assumed for GLONASS may be insufficiently protective.

Note 2: GLONASS operates with spread spectrum signals. The amount of processing gain (if any) to be applied with respect to Aries signals is uncertain.

Note 3: From Application, Appendix J.

Note 4: Assumed that earth blockage provides adequate attenuation.